	Document #	Date Effective
	LAT-SS-00016-R3 (would have been D13)	Draft 2/08/02
	Responsible Engineer(s) M. Amato, G. Shiblie, B Hartman, D. Thompson	Supersedes None
GLAST LAT SUBSYSTEM SPECIFICATION	Subsystem/Office ACD Subsystem	
Document Title **LAT ACD Subsystem Specification - Level III Specification**		

Gamma-ray Large Area Space Telescope

(GLAST)

Large Area Telescope (LAT)

Anticoincidence Detector (ACD)

Subsystem Specification/Requirements

CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes	DCN #
1	1/4/02	Initial Release	LAT-XR-406.1
2	2/08/02	Eliminated pure text section of reqs and put all info in table only. Added links to level 2 reqs, corrected old info, clarified confusions. Added trigger width and delay changes initially proposed by LAT.	LAT-XR-TBD

ACD Approvals

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CONTENTS

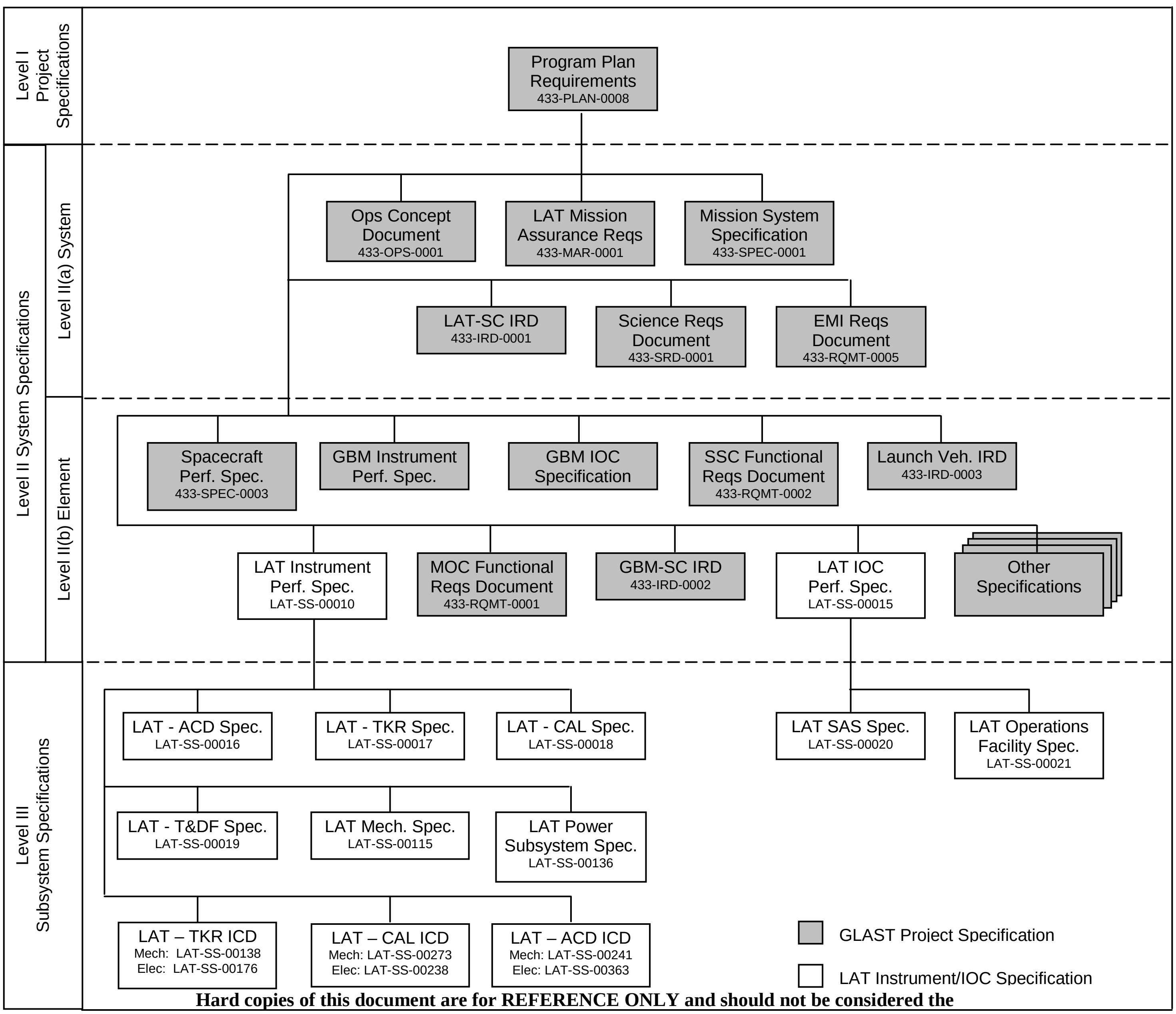
1 PURPOSE

This document defines level III subsystem requirements for the GLAST Large Area Telescope (LAT) Anticoincidence Detector (ACD).

2 SCOPE

This specification captures the GLAST LAT requirements for the ACD. This encompasses the subsystem level requirements and the design requirements for the ACD. The verification methods of each requirement are identified. This specification is identified in the specification tree of Figure 2-1.

Figure 2-1 LAT Specification Tree



3 Definitions

3.1 Acronyms

ACD - Anticoincidence Device

EDAQ – Electronics and Data Acquisition Subsystem

FOV – Field of View

GLAST – Gamma-ray Large Area Space Telescope

IOC – Instrument Operations Center

IRD – Interface Requirements Document

LAT – Large Area Telescope

MIP – Minimum Ionizing Particle (see definition below)

MSS – Mission System Specification

PI – Principal Investigator

SAS – Science Analysis Software

SI/SC IRD – Science Instrument – Spacecraft Interface Requirements Document

SRD – Science Requirements Document

SSC – Science Support Center

TBR – To Be Resolved

TEM - Tower Electronics Module

3.2 Definitions

μsec, μs – Microsecond, 10^{-6} second

Analysis – A quantitative evaluation of a complete system and /or subsystems by review/analysis of collected data.

Background Rejection – The ability of the instrument to distinguish gamma rays from charged particles.

Backsplash – Secondary particles and photons originating from very high-energy gamma-ray showers in the calorimeter giving unwanted ACD signals.

cm – centimeter

Cosmic Ray - Ionized atomic particles originating from space and ranging from a single proton up to an iron nucleus and beyond.

Dead Time – Time during which the instrument does not sense and/or record gamma ray events during normal operations.

Demonstration – To prove or show, usually without measurement of instrumentation, that the project/product complies with requirements by observation of results.

eV – Electron Volt

Field of View – Integral of effective area over solid angle divided by peak effective area.

GeV – Giga Electron Volts. 10^9 eV

Inspection – To examine visually or use simple physical measurement techniques to verify conformance to specified requirements.

MeV – Million Electron Volts, 10^6 eV

Minimum Ionizing Particle – The mean signal from cosmic ray produced air shower muons at sea level normally incident on a scintillator tile. It corresponds to approximately 1.9 MeV per cm of scintillator.

nsec – Nanosecond, 10^{-9} second

ph – photons

s, sec – seconds

Simulation – To examine through model analysis or modeling techniques to verify conformance to specified requirements

Testing – A measurement to prove or show, usually with precision measurements or instrumentation, that the project/product complies with requirements.

Validation – Process used to assure the requirement set is complete and consistent, and that each requirement is achievable.

Verification – Process used to ensure that the selected solutions meet specified requirements and properly integrate with interfacing products.

VETO - The signal from an individual ACD scintillator tile that indicates an energy deposit of at least ~0.3 MIP (~500 keV) in an ACD scintillator tile, or about 20% of that amount in one of the scintillating fiber ribbons. This threshold is set to be exceeded for a very high fraction of MIPs in the presence of all fluctuations in their energy deposit in the scintillator tiles. The VETO signals from individual tiles and ribbons are combined with information from the tracker and calorimeter to decide whether or not to reject events as background.

4 APPLICABLE DOCUMENTS

Documents that are relevant to the development of the ACD concept and its requirements include the following:

LAT-SS-00010, “GLAST LAT Performance Specification”, August 2000

LAT Performance Specification - Level II(b) Specification, LAT-SS-00010-1

LAT-SS-00047, “LAT Mechanical Performance Specification”

“GLAST Large Area Telescope Flight Investigation: An Astro-Particle Physics Partnership Exploring the High-Energy Universe”, proposal to NASA, P. Michelson, PI, November, 1999

LAT-ACD Subsystem Mechanical Interface Control Document, LAT-SS-00241

LAT-ACD Subsystem Electrical Interface Control Document, LAT-SS-00363

433-SRD-0001, “GLAST Science Requirements Document”, September 23, 2000.

5 REQUIREMENTS

5.1 System Description and Level III Requirements Table

The LAT science instrument (SI) consists of an Anticoincidence Device (ACD), a silicon-strip detector tracker (TKR), a hodoscopic CsI calorimeter (CAL), and a Trigger and Dataflow system (T&DF). The principal purpose of the SI is to measure the incidence direction, energy and time of cosmic gamma rays. The measurements are streamed to the spacecraft for data storage and subsequent transmittal to ground-based analysis centers.

The ACD detects energetic cosmic ray electrons and nuclei for the purpose of removing these backgrounds. It is the principle source for detection of other than gamma-ray particles. This detector element covers the TKR. It consists of an array of 89 plastic scintillator tiles (1 cm thick, various sizes), plus 12 scintillating fiber "ribbons" that cover the gaps between the tiles. Each tile is read out by two PMT's. Signals produced by the ACD are used by the T&DF system to identify cosmic ray electrons and nuclei entering the instrument. The ACD level III requirements along which LAT level IIb requirements or other sources from which they derive are listed in the Requirements Table below.

Requirements Table

Note: Verification methods are T = Test, A = Analysis, D = Demonstrate, I = Inspect

Req't #	Title	Summary	Verif. Method	LAT L2(b) Req flow

5.2	Detection of Charged Particles	The ACD shall detect energy deposits with energies of above an adjustable threshold nominally at 0.3 MIP (minimum ionizing particle) (see 5.3 below) and produce VETO signals.	T	L2(b) 5.2.12, & Sci. Sim.
5.3	Adjustable Threshold on Detecting Charged Particle	The threshold for VETO detection of charged particles shall be adjustable from 0.1 to 2.0 MIP, with a step size of ≤0.05 MIP. (0.1 to 0.6 MIP would have been range if no degradation was expected)	T	L2(b) 5.2.12 & Sci. Sim
5.4	Detection Efficiency	The average detection efficiency for minimum ionizing particles shall be at least 0.9997 over the entire area of the ACD (except for the bottom tiles on each side, for which the efficiency shall be at least .99 , simulation confirmation of this number is desired at some point).	T, A	L2(b) 5.2.12 & Sci. Sim
5.5	Instrument Coverage	The ACD shall cover the top and sides of the LAT tracker down to the top of the CsI. The top of all 4 sides of the ACD scintillator shall be extended upward so as to be at least as high as the highest point in the micrometeoroid/debris shield.	I	L2(b) 5.2.12 & Sci. Sim
5.6	Mean Thickness	The ACD, support structure, and micrometeroid shield shall have a mean thickness less than 0.04 radiation lengths.	A	L2(b) 5.2.3 & Sci. Sim
5.7	False VETO due to Backsplash	The ACD shall be segmented so that no more than 20% of otherwise-accepted gamma-ray events at 300 GeV shall be rejected by false VETOES due to calorimeter backsplash. (Note: may add req 5.7.2 - dead time req - linked to L2(b) 5.2.3)	A	L2(b) 5.2.1 & Sci. Sim
5.8	False VETO due to Electrical Noise	The false VETO signal rate due to noise shall result in a rejection of no more than 1% of triggered gamma rays.	A	L2(b) 5.2.3 & Sci. Sim

5.9	High-Threshold Detection	The ACD shall detect highly-ionizing particles (carbon-nitrogen-oxygen or heavier nuclei, denoted High-Threshold) depositing energy greater than 25 times a MIP and shall provide a signal to the AEM (for CAL calibration - I.e. energy res, -also see Level 4 req 5.8.7 discriminator masking req)	A	L2(b) 5.2.2
5.10	Adjustable High-Threshold	The High-Threshold shall be adjustable from 20 to 64 MIP in steps of ≤1 MIP.	A	L2(b) 5.2.2
5.11.1	Fast VETO Signal	For each PMT, a fast VETO signal shall be generated when the its VETO threshold is exceeded.	D	L2(b) 5.2.12, & L3 5.2
5.11.2	Fast VETO Signal Latency	The fast VETO signal latency shall be commandable from 200 - 1600 nsec after particle passage.	T	L2(b) 5.2.3 & Sci. Sim
5.11.3	Logic VETO Signal	A map of the tiles that produce VETO signals shall be generated for each Level 1 Trigger Acknowledge.	D	L2(b) 5.2.3 & Sci. Sim
5.11.4	Logic VETO Signal Latency	The map of VETO signals shall be latched by the time the ADC's conversions are completed	T	L2(b) 5.2.3 & Sci. Sim
5.11.5	Logic VETO Signal Timing	The logic VETO map shall represent the state of all ACD discriminators at the time of the particle passage (±250 ns TBD) causing the Level 1 Trigger Acknowledge.	T	L2(b) 5.2.3 & Sci. Sim
5.11.6	Fast VETO Signal Width	The fast VETO output signal shall have a commandable width of 50 – 400 nsec, after ‘de-glitching’ on 2 successive clock pulses. The leading and trailing edges must be synchronous with clock pulses.	T	L2(b) 5.2.3 & Sci. Sim
5.11.7	Logic VETO Recovery Time for Large Signals	For a signal equivalent to 200 MIP's, the logic VETO signal shall be no longer than 10 microseconds (current design will be <5 microseconds).	D	L2(b) 5.2.3 & Sci. Sim

5.11.8	High-Threshold Signal Latency	A highly-ionizing particle hitting the top or upper side row of tiles of the ACD shall produce a High-Threshold fast signal to the hardware trigger logic with latency timing characterized as required in specification 5.11.2 and 5.11.6	A	L2(b) 5.2.2 & Sci. Sim *
5.11.9	ACD Trigger Primitives	The ACD will produce no trigger primitives internally. The VETO signals caused by the individual PMT's will be transmitted to the LAT AEM's, where they will be OR'ed together (for each tile or ribbon), and used by the the AEM's to generate trigger primitives.	T	L2(b) 5.2.12, L2(b) 5.2.3, & Sci. Sim
5.12	ACD Performance Monitoring	The ACD electronics shall collect and transmit sufficient pulse height, and temperature information to monitor the status and performance of the ACD system and maintain its calibration to 5%. The LAT AEM's will generate and transmit count rates for ACD signals. A low-threshold signal will allow zero suppression of the pulse height data transmission to the data acquisition system. ACD voltages and currents will be monitored on the LAT side of the interface. Current thermal information is one single thermistor per board, we are considering more thermistors on structure.	D, T	L2(b) 5.2.12 & Sci. Sim
5.12.1	Low-Threshold Signal	The ACD shall detect energy deposits above an adjustable threshold nominally at 0.1 MIP and produce Low-Threshold signals.	D	L2(b) 5.2.12 & Sci. Sim
5.12.2	Low-Threshold Adjustability	The Low-Threshold shall be adjustable from 0.05 to 0.3 MIP, with a step size of $\leq$0.05 MIP (.032 pC).	D	L2(b) 5.2.12 & Sci. Sim

5.12.3	Signal Content	When a Level 1 Trigger Acknowledge is received, the ACD electronics shall collect and transmit sufficient information to determine the pulse height up to 200 MIP (was previously 1000,) with the following precision: - for a pulse below 10 MIP, precision of <0.02 MIP or 5%, whichever is larger; - for a pulse above 10 MIP, precision of <1 MIP or 2%, whichever is larger.	D	L2(b) 5.2.12
5.12.4	Pulse Digitization	Upon a Level 1 Trigger Acknowledge, all tile and ribbon pulses shall be digitized.	A, T	L2(b) 5.2.12
5.12.5	Pulse Height Measurement Latency	The pulse height measurements shall be completed within 18.5 microseconds after a Level 1 trigger is received. (Transmission not included in 18.5 microseconds.)	A, T ?	L2(b) 5.2.12
5.12.6	Housekeeping	ACD shall make available other housekeeping and monitoring as deemed needed or required in ICD	D ?	L2(b) 5.3.4, Electronics ICD
5.13	Reliability - Electronics	No single failure in the ACD electronics shall result in the loss of signal from both PMT's on any single tile. The probability of the loss of both VETO signals from any scintillator tile due to electronics failures shall be less than 1% in 5 years. The probability of the loss of VETO signals from any scintillator ribbon due to electronics failures shall be less than 5% in 5 years. The ACD reliability allotment from LAT is currently .96 over 5 years. (Note:2% and 10% respectively are used in a few older documents – double check 1% and 5% numbers)	A	L2(b) 5.3.2
5.14	Reliability - Tiles	The loss of any one detector element (tile or ribbon) shall not result in the loss of any other element.	A	L2(b) 5.3.2

5.15	Testability	ACD shall be testable to confirm performance and requirements are met (except when cost and complexity of creating direct testibilty very clearly outweighs benifit)	T	
5.16	Reliability - Mechanical/Optical	The probability of the loss of both VETO signals from any scintillator tile due to mechanical or optical failures shall be less than 1% in 5 years. The probability of the loss of VETO signals from any scintillator ribbon due to mechanical or optical failures shall be less than 5% in 5 years. The ACD reliability allotment from LAT is currently .96 over 5 years.	A	L2(b) 5.3.2
5.17.1	Detector On/Off Commands	The ACD shall implement commands to allow each group of 18 PMT's to be separately powered on and off.	T	L2(b) 5.3.2
5.17.2	Detector Gain Commands	The ACD shall implement commands to allow the HV of each group of 18 PMT's to be separately adjusted.	T	L2(b) 5.3.2
5.17.3	Electronics On/Off Commands	The ACD shall implement commands to allow each electronics board to be separately powered on and off.	T, D	L2(b) 5.3.2
5.17.4	VETO Threshold Commands	The ACD shall implement commands to set the VETO threshold for each PMT.	T, D	L2(b) 5.3.2
5.17.5	High-Threshold Commands	The ACD shall implement commands to set the High-Threshold for each PMT.	T, D	L2(b) 5.3.2
5.17.6	ACD Monitoring Commands	The ACD shall implement commands to allow the Instrument Operator to adjust the monitoring functions of the ACD electronics, including the Low-Threshold for each PMT.	T, A	L2(b) 5.3.2
5.17.7	Low-Gain Mode Commands	The ACD shall implement commands to switch the ACD PMT's into and out of low-gain mode for high counting rate conditions.	T	L2(b) 5.3.2
5.18	Power	The ACD total electronics power	D, A	L2(b) 5.3.10, &

	Consumption	consumption shall not exceed 31 W conditioned.		ELECT ICD
5.19	Mass	The total mass of the ACD and micrometeoroid shield shall not exceed 228 Kg. (ACD has requested (~Nov 2001) and received (Feb 2002) this change from 205 Kg).	D	L2(b) 5.3.6, Mech ICD - LAT-SS-241
5.20	Center of Mass	The center of mass of the ACD and micrometeoroid shield shall be located within 400 mm of the top of the mechanical grid structure. (Note: clarify, was 393 mm, x and y dimension reqs never specified by LAT, +/- 5mm for both (from center of grid?) proposed by ACD at PDR)	T	L2(b) 5.3.7, Mech ICD - LAT-SS-241
5.21	Environmental	The ACD shall meet the structural, thermal, EM and radiation environment requirements defined in the Mech ICD - LAT-SS-241, Elect ICD-LAT-SS-363 and L2 reqs	T, D, A	L2(b) 5.3.12, L2(b)?, Mech ICD - LAT-SS-241, Elect ICD-LAT-SS-363
5.22	Physical Size	The dimensions of the ACD plus the micrometeoroid shield shall conform to the requirements in the Interface Control Documents, LAT-SS-241, LAT-SS-363 and LAT dwgs LAT-DS-0038 and 00309.	D	L2(b) 5.3.8, Mech ICD - LAT-SS-241 ?
5.23.1	Thermal Blanket/ Micrometeoroid Shield Areal Mass Density	The thermal blanket/micrometeoroid shield shall have mass per unit area which minimizes secondary gamma-ray production by undetected cosmic ray interactions.	D, A	L2(b) 5.2.12
5.23.2	Micrometeoroid Protection	The thermal blanket/micrometeoroid shield shall minimize the probability that micrometeoroids and space debris will penetrate and create a light path to the ACD scintillators. The mean rate of such penetrations over the entire shield shall be less than 0.01/yr	A	L2(b) 5.3.2

5.23.3	Thermal Control	The thermal blanket/micrometeoroid shield shall have thermal properties (absorptance, reflectance, and transmittance) as required to maintain the temperatures described in the LAT Mechanical ICD - LAT-SS-241	A	L2(b) 5.3.11
5.24	Performance Life	The ACD shall maintain the specified performance for a minimum of five years in orbit.	A	L2(b) 5.3.2
5.25	Operation in High Rate Conditions	The ACD photomultiplier bias supplies shall switch into a low-gain mode to protect the phototubes in very high intensity particle conditions (> 10 kHz in an individual tile) such as the South Atlantic Anomaly. (Accomplished by HVBS command from AEM to GARC)	A	L2(b) 5.3.2
5.25.1	Notification of Mode Change	The ACD shall be able to tell (via voltage monitoring and command log) when it switches into low-gain mode for high counting rate conditions.	D, T	L2(b) 5.3.2
5.25.2	Rate Requirement for Operation within Specification	Each ACD PMT and its associated electronics shall be capable of operating within the specifications above at MIP rates up to 3 kHz	D, T	L2(b) 5.3.2

6 VERIFICATION STRATEGY

The verification strategy will test, analyze (may include modeling/simulation), inspect, or demonstrate all requirements of section 5 to ensure that the instrument meets the requirements of this specification. The verification column above indicates the basic verification method for each requirement. See the ACD integration and test plan document (LAT-TD-00430) for the test matrix, verification matrix and more detail.